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Effect of Infrared Radiation on External Tank (ET)Thermal Protection System (TPS) Technical Consultation Report

November 17, 2005

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1.0 Authorization and Notification

The request to conduct a real-time consultation was submitted to the NASA Engineering and Safety Center (NESC) on May 20, 2005.

NESC participation in the External Tank (ET) Infrared (IR) effects activity took place between May 20 and June 15, 2005.


A final report will be presented to the NESC Review Board (NRB) on November 17, 2005.

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2.0 Signature Page

Timmy R. Wilson, Team Lead


Bruce Banks

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3.0 Team Members

Team Members


Name	Position/SPRT Affiliation	Location
Timmy R. Wilson	NESC Chief Engineer	KSC
Bruce Banks	Chief, Electro-Physics Branch	GRC
Support		
Elizabeth Holthofer	Technical Writer	ViGYAN, Inc., LaRC

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4.0 Executive Summary


The NESC was asked to participate in a review and provide technical input regarding the use of IR lamps for heating the Space Shuttle ET foam to prevent ice formation on exposed metallic components. Concern over appropriate lamp power levels and effects of IR radiation on the TPS prompted the review and subsequent NESC involvement.

Personnel at the Glenn Research Center (GRC) participated in this effort for NESC and conducted tests to ascertain the spectral absorbance of ET foam. Test data was provided to the Space Shuttle Program (SSP).

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5.0 Consultation

The scope of this consultation was limited to participation in ET IR effects discussion and testing of ET foam samples provided by the SSP. This consultation was considered a quick turnaround peer review and, therefore, no consultation plan was generated prior to this review.

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6.0 Description of the Problem, Proposed Solutions, and Risk Assessment

The SSP Kennedy Space Center (KSC) Launch and Landing Project developed a prototype system for warming exposed areas of the ET with IR lamps as a means of preventing ice formation on exposed metallic surfaces of the tank. Figures 6.0-1 and 6.0-2 depict the proposed location of light banks during launch and the lights themselves. Concerns were voiced over the potential for damage to the ET foam from the IR emitted by the light bank. NESC participated in the ensuing technical discussions and conducted testing to determine the spectral absorbance of ET foam using samples provided by the SSP.

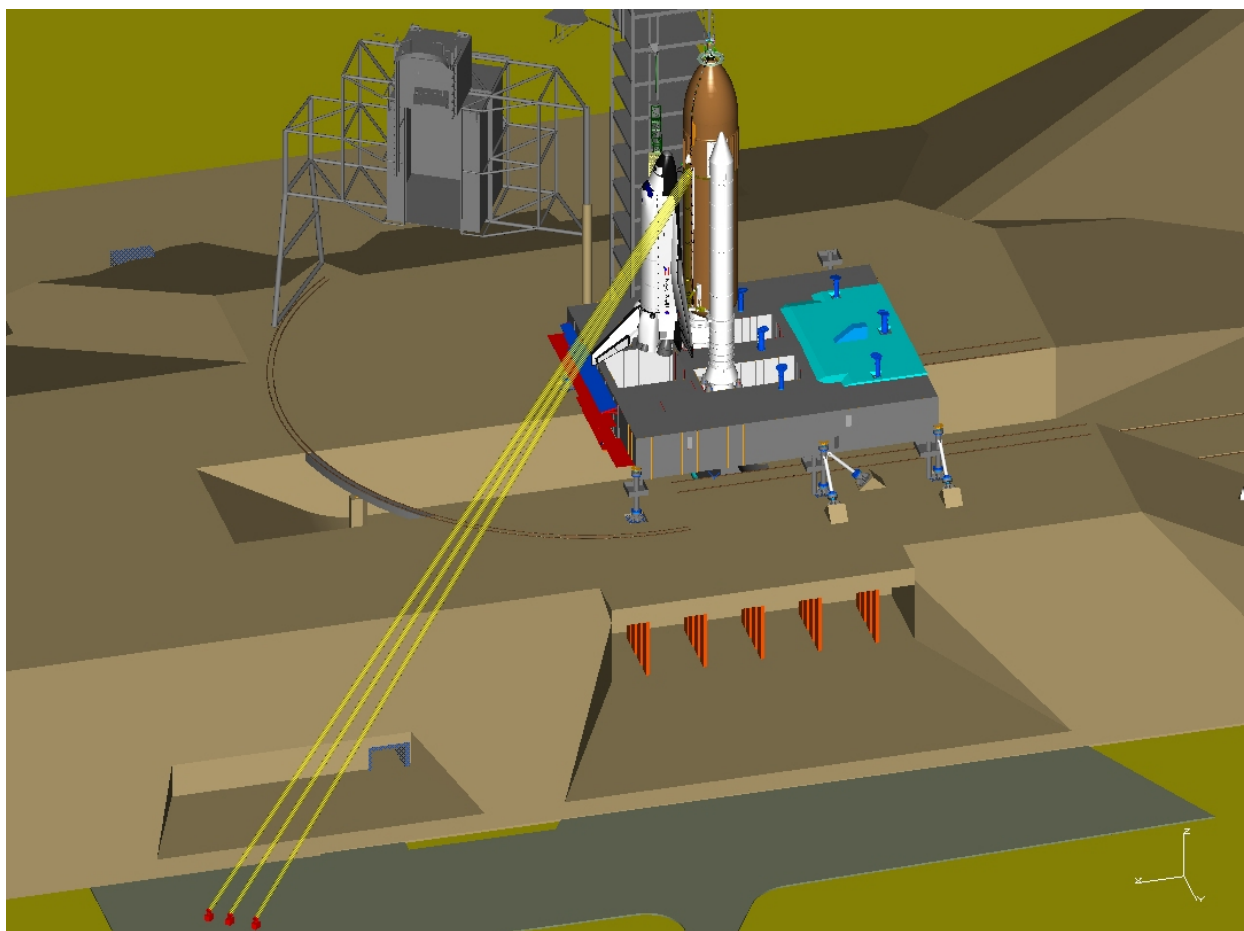


Figure 6.0-1. IR Light Bank Location



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Figure 6.0-2. IR Light Bank

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7.0 Data Analysis

Samples of ET-120 aged foam were provided by the SSP at KSC and evaluated by the Electro-Physics Branch at GRC. One difficulty was encountered with the size of samples: the samples were about 0.5 inches wide and needed to be 1 inch wide for test purposes. Two 0.5 inch samples were clamped together with only a very small force such that there was no gap between them during optical measurements. Spectral absorptance was measured as a function of wavelength from 0.25 microns (250 nm) to 25 microns (25,000 nm) using two instruments, a Perkin Elmer Lambda-19 for the range from 0.25 to 2.5 microns and a SOC-400T for the range from 2.5 to 25 microns. Data appeared to fit smoothly from one instrument to the other and is presented in Figure 7.0-1. It should be noted that tests were conducted on dry samples. If the foam becomes wet due to condensation of moisture from the air or any other source, spectral absorptance of actual foam could differ from that of the samples tested.

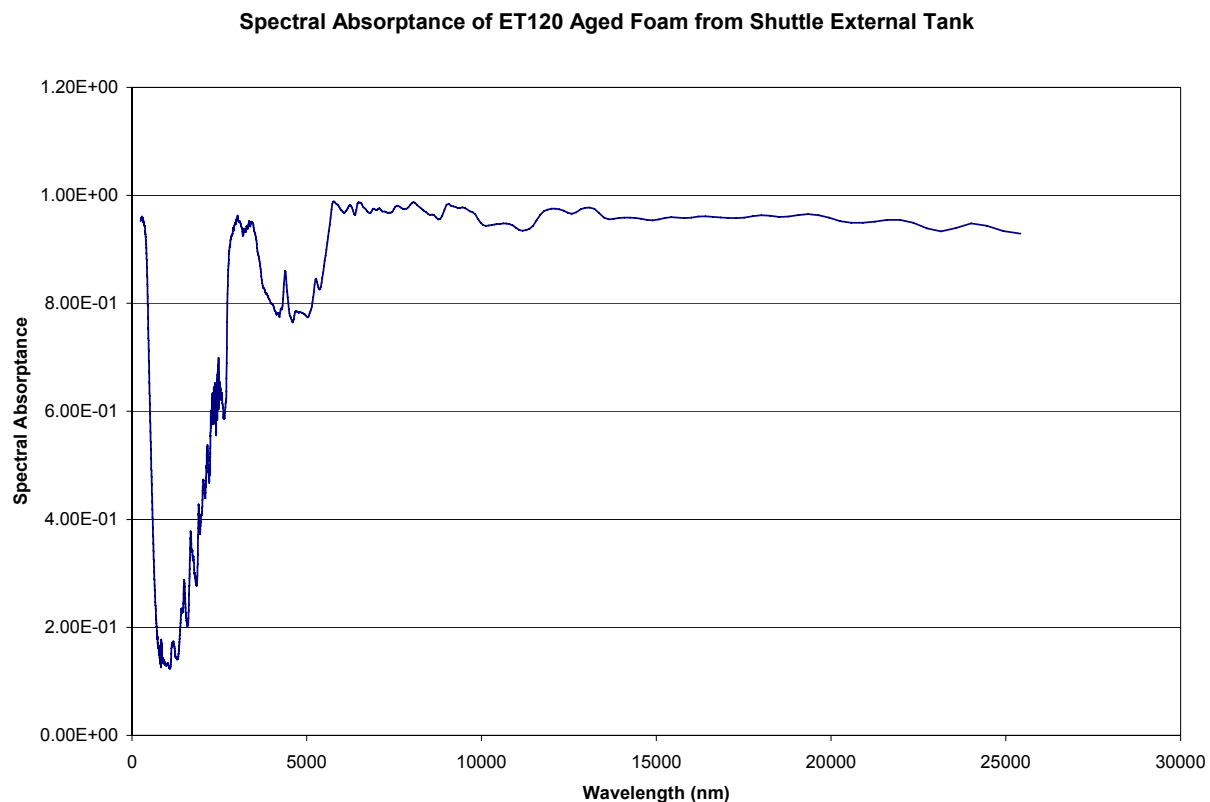




Figure 7.0-1. ET-120 Foam Spectral Absorptance

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8.0 Findings, Observations and Recommendations

The team made real-time inputs during the review process. Test data was provided as discussed in Section 7.0. No significant findings, observations, or recommendations were generated.

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9.0 Lessons Learned

NESC participation was limited to assembly of a knowledgeable team with experience in spectral absorptance and conduct of testing on ET TPS samples provided by the SSP. No significant lessons-learned were generated.

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10.0 Definition of Terms

Absorption	A measure of the rate of decrease in the intensity of electromagnetic radiation (as light) as it passes through a given substance; the fraction of incident radiant energy absorbed per unit mass or thickness of an absorber; "absorptance equals 1 minus transmittance."
Corrective Actions	Changes to design processes, work instructions, workmanship practices, training, inspections, tests, procedures, specifications, drawings, tools, equipment, facilities, resources, or material that result in preventing, minimizing, or limiting the potential for recurrence of a problem.
Finding	A conclusion based on facts established during the assessment/inspection by the investigating authority.
Lessons Learned	Knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure. A lesson must be significant in that it has real or assumed impact on operations; valid in that it is factually and technically correct; and applicable in that it identifies a specific design, process, or decision that reduces or limits the potential for failures and mishaps, or reinforces a positive result.
Observation	A factor, event, or circumstance identified during the assessment/inspection that did not contribute to the problem, but if left uncorrected has the potential to cause a mishap, injury, or increase the severity should a mishap occur.
Problem	The subject of the technical assessment/inspection.
Requirement	An action developed by the assessment/inspection team to correct the cause or a deficiency identified during the investigation. The requirements will be used in the preparation of the corrective action plan.
Root Cause	Along a chain of events leading to a mishap or close call, the first causal action or failure to act that could have been controlled systemically either by policy/practice/procedure or individual adherence to policy/practice/procedure.

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11.0 List of Acronyms

NASA	National Aeronautics and Space Administration
NESC	NASA Engineering & Safety Center
NRB	NESC Review Board
ET	External Tank
TPS	Thermal Protection System
IR	Infrared
KSC	Kennedy Space Center
GRC	Glenn Research Center
LaRC	Langley Research Center
SSP	Space Shuttle Program

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12.0 Minority Report (Dissenting Opinions)

There were no dissenting opinions during this consultation.


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Volume II: Appendices


Appendix A. NESC Request (PR-003-FM-01, v. 1.0)

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NASA Engineering and Safety Center Request Form		
Submit this ITA/I Request, with associated artifacts attached, to: nrbexecsec@nasa.gov , or to NRB Executive Secretary, M/S 105, NASA Langley Research Center, Hampton, VA 23681		
Section 1: NESC Review Board (NRB) Executive Secretary Record of Receipt		
Received (mm/dd/yyyy h:mm am/pm) 5/20/2005 12:00 AM	Status: New	Reference #: 05-031-E
Initiator Name: Billy Stover	E-mail: Billy.R.Stover@nasa.gov	Center: KSC
Phone: (321)-861-8554, Ext _____	Mail Stop:	
Short Title: Effect of Infrared Radiation (IR) Lamp Irradiation on External Tank (ET) Thermal Protection System		
Description: NESC was asked to support an analysis of the hardware being developed to project IR radiation onto the External Tank during loading to minimize the potential for frost and ice formation. Questions over the appropriate power level and effects of IR on the ET Thermal Protection System have arisen that the development team is attempting to address through test and analysis.		
Source (e.g. email, phone call, posted on web): email		
Type of Request: Consultation		
Proposed Need Date:		
Date forwarded to Systems Engineering Office (SEO): (mm/dd/yyyy h:mm am/pm):		
Section 2: Systems Engineering Office Screening		
Section 2.1 Potential ITA/I Identification		
Received by SEO: (mm/dd/yyyy h:mm am/pm): 5/23/2005 12:00 AM		
Potential ITA/I candidate? <input type="checkbox"/> Yes <input type="checkbox"/> No		
Assigned Initial Evaluator (IE):		
Date assigned (mm/dd/yyyy):		
Due date for ITA/I Screening (mm/dd/yyyy):		
Section 2.2 Non-ITA/I Action		
Requires additional NESC action (non-ITA/I)? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
If yes:		
Description of action: Support the analysis of the hardware being developed to project IR radiation on the ET.. This is related to Return-to-flight and was approved Out-of-Board by Ralph Roe on 5/23/2005.		
Actionee: Tim Wilson		
Is follow-up required? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No If yes: Due Date:		
Follow-up status/date:		
If no:		
NESC Director Concurrence (signature):		
Request closure date: .		

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Section 3: Initial Evaluation			
Received by IE: (mm/dd/yyyy h:mm am/pm):			
Screening complete date:			
Valid ITA/I candidate? <input type="checkbox"/> Yes <input type="checkbox"/> No			
Initial Evaluation Report #: NESC-PN-			
Target NRB Review Date:			
Section 4: NRB Review and Disposition of NCE Response Report			
ITA/I Approved: <input type="checkbox"/> Yes <input type="checkbox"/> No		Date Approved:	
ITA/I Lead: , Phone () - , x		Priority: - Select -	
Section 5: ITA/I Lead Planning, Conduct, and Reporting			
Plan Development Start Date:			
ITA/I Plan # NESC-PL-			
Plan Approval Date:			
ITA/I Start Date	Planned:	Actual:	
ITA/I Completed Date:			
ITA/I Final Report #: NESC-PN-			
ITA/I Briefing Package #: NESC-PN-			
Follow-up Required? <input type="checkbox"/> Yes <input type="checkbox"/> No			
Section 6: Follow-up			
Date Findings Briefed to Customer:			
Follow-up Accepted: <input type="checkbox"/> Yes <input type="checkbox"/> No			
Follow-up Completed Date:			
Follow-up Report #: NESC-RP-			
Section 7: Disposition and Notification			
Notification type: - Select -		Details:	
Date of Notification:			
Final Disposition: - Select -			
Rationale for Disposition:			
Close Out Review Date:			

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Form Approval and Document Revision History

Approved: _____ NESC Director	_____ Date
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Version	Description of Revision	Office of Primary Responsibility	Effective Date
1.0	Initial Release	Principal Engineers Office	29 Jan 04

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Approval and Document Revision History

<div style="display: flex; justify-content: space-between; align-items: flex-end;"> <div style="text-align: center;"> Approved: _____ NESC Director </div> <div style="text-align: center;"> Original signed on file _____ </div> <div style="text-align: center;"> 12/9/05 Date </div> </div>

Version	Description of Revision	Office of Primary Responsibility	Effective Date
1.0	Initial Release	NESC Chief Engineer's Office	